

Having described the invention, we claim:

1. A steering system for a vehicle having opposite first and second steerable wheels, said steering system comprising:

a housing having first and second end portions and an intermediate portion;

a steering member having a longitudinal axis, said steering member being supported in a chamber in said housing for axial movement relative to said housing;

a piston movable with said steering member, said piston having first and second opposite end faces;

a first spring member engaging said first end face of said piston and biasing said piston and thereby said steering member in a first axial direction toward a straight ahead position;

a second spring member engaging said second end face of said piston and biasing said piston and thereby said steering member in a second axial direction opposite said first axial direction toward a straight ahead position;

first steering linkage connected with said piston for transmitting movement of said piston to said first steerable wheel; and

second steering linkage connected with said piston for transmitting movement of said piston to said second steerable wheel.

2. A system as set forth in claim 1 further comprising an electric motor located outside said chamber and a drive belt drivingly connected between said electric motor and said steering member for driving said steering member axially upon actuation of said electric motor.

3. A system as set forth in claim 2 wherein said steering member has a screw thread portion adjacent said electric motor, and further comprising a ball nut associated with said screw thread portion of said steering member and fixed axially in said housing, said drive belt being drivingly connected between said electric motor and said ball nut to effect rotation of said ball nut and thereby axial movement of said steering member upon actuation of said electric motor.

4. A system as set forth in claim 3 wherein said steering member is free of rack teeth.

5. A steering system as set forth in claim 2 further comprising motor control circuitry selectively operative to cause the generation of back EMF in said motor in order to resist movement of said steering member toward the straight ahead position.

6. A system as set forth in claim 1 wherein said housing has a takeoff opening located in said intermediate portion of said housing and a belt opening, said system comprising a takeoff assembly portion projecting from said takeoff opening between said piston and said first and second steering linkages, said housing further comprising a belt opening spaced axially from said takeoff opening, said system comprising a drive belt extending through said belt opening into said housing to transmit drive force to move said steering member axially.

7. A system as set forth in claim 6 wherein said steering member has a screw thread portion radially inward of said belt opening for receiving force to drive said steering member axially, said steering member being free of rack teeth.

8. A system as set forth in claim 1 comprising a locking member for locking said steering member in the straight ahead position after movement of said steering member to the straight ahead position by said first spring member and said second spring member.

9. A steering system for a vehicle having opposite first and second steerable rear wheels, said steering system comprising:

a housing having first and second end portions and an intermediate portion, said housing defining a chamber;

a steering member having a longitudinal axis, said steering member being supported in said chamber of said housing for axial movement relative to said housing, said steering member having a screw thread portion;

a ball nut associated with said screw thread portion of said steering member and fixed axially in said chamber of said housing;

an electric motor located outside said chamber of said housing;

a drive belt connected between said electric motor and said ball nut for rotating said ball nut to

drive said steering member axially upon actuation of said electric motor;

a takeoff assembly fixed for movement with said steering member, said takeoff assembly having a portion projecting radially from said intermediate portion of said housing;

first steering linkage connected with said projecting portion of said takeoff assembly for transmitting movement of said takeoff assembly to said first steerable rear wheel;

second steering linkage connected with said projecting portion of said takeoff assembly for transmitting movement of said takeoff assembly to said second steerable rear wheel; and

a spring mechanism acting between said takeoff assembly and said housing, said spring mechanism biasing said takeoff assembly and thereby said steering member a straight ahead position.

10. A steering system as set forth in claim 9 wherein said spring mechanism comprises a single spring acting to bias said steering member in a first axial direction toward a straight ahead position when said steering member is moved from the straight ahead position

in a second axial direction opposite the first axial direction, and in the second axial direction toward the straight ahead position when said steering member is moved from the straight ahead position in the first axial direction.

11. A steering system as set forth in claim 10 wherein said housing has stops that capture said spring between said housing stops, said steering member has stops that capture said spring between said steering member stops, and said steering member stops are movable relative to said housing stops to compress said spring upon movement of said steering member from the straight ahead position.

12. A steering system as set forth in claim 10 further comprising an electric motor for driving said steering member axially relative to said housing, said piston being located axially between said electric motor and said single spring.

13. A steering system as set forth in claim 10 further comprising first means spaced apart from said piston and acting between said single spring and said steering member for transmitting biasing force of said

single spring to said steering member, and second means spaced apart from said piston and acting between said single spring and said housing for transmitting biasing force of said single spring to said housing.

14. A steering system as set forth in claim 9 wherein said spring mechanism comprises a first spring member acting between said takeoff assembly and said housing, said first spring member biasing said takeoff assembly and thereby said steering member in a first axial direction toward a straight ahead position, and a second spring member acting between said takeoff assembly and said housing, said second spring member biasing said takeoff assembly and thereby said steering member in a second axial direction opposite the first axial direction toward the straight ahead position.

15. A steering system as set forth in claim 14 wherein said takeoff assembly comprises a piston member movable with said steering member, said piston member having first and second opposite end faces, said first spring member engaging said first end face of said piston member and biasing said piston member and thereby said steering member in said first axial direction and said second spring member engaging said second end face of

said piston member and biasing said piston member and thereby said steering member in said second axial direction.

16. A steering system as set forth in claim 15 wherein said piston member is formed as one piece with said steering member.

17. A steering system as set forth in claim 9 wherein said steering member is free of rack teeth.

18. A steering system as set forth in claim 9 wherein said housing is an axle, said first and second end portions of said housing supporting the first and second rear wheels of the vehicle, said intermediate portion of said axle defining said chamber in said axle.

19. A steering system as set forth in claim 9 further comprising motor control circuitry operative to cause the generation of back EMF in said motor in order to resist movement of said steering member toward the straight ahead position.

20. A system as set forth in claim 9 comprising a locking member for locking said steering member in the straight ahead position after movement of said steering



member to the straight ahead position by said first spring member and said second spring member.

21. A steering system for a vehicle having first and second steerable rear wheels, said steering system comprising:

an axle having first and second end portions that support the first and second rear wheels of the vehicle, said axle having an intermediate portion defining a chamber in said axle;

an elongate steering member having a longitudinal central axis, said steering member being supported in said chamber in said axle for axial movement relative to said axle, said steering member having a screw thread portion and being fixed from rotation in said axle;

a ball nut associated with said screw thread portion of said steering member and fixed axially in said chamber in said axle;

an electric motor located outside said chamber of said axle;

a drive belt connected between said electric motor and said ball nut for rotating said ball nut to

drive said steering member axially upon actuation of said electric motor;

a takeoff assembly fixed to said steering member and having a portion projecting from an opening in said intermediate portion of said axle;

first steering linkage connected with said projecting portion of said takeoff assembly for transmitting movement of said takeoff assembly to said first steerable rear wheel; and

second steering linkage connected with said projecting portion of said takeoff assembly for transmitting movement of said takeoff assembly to said second steerable rear wheel.

22. A steering system as set forth in claim 21 further comprising a spring mechanism acting between said takeoff assembly and said axle, said spring mechanism biasing said takeoff assembly and thereby said steering member toward a straight ahead position.

23. A steering system as set forth in claim 22 wherein said spring mechanism comprises a single spring acting to bias said steering member in a first axial direction toward a straight ahead position when said steering member is moved from the straight ahead position

in a second axial direction opposite the first axial direction, and to bias said steering member in the second axial direction toward the straight ahead position when said steering member is moved from the straight ahead position in the first axial direction.

24. A steering system as set forth in claim 23 wherein said housing has stops that capture said spring between said housing stops, said steering member has stops that capture said spring between said steering member stops, and said steering member stops are movable relative to said housing stops to compress said spring upon movement of said steering member from the straight ahead position.

25. A steering system as set forth in claim 22 further comprising an electric motor for driving said steering member axially relative to said housing, said takeoff assembly comprising a piston located axially between said electric motor and said single spring.

26. A steering system as set forth in claim 25 further comprising first means spaced apart from said piston and acting between said single spring and said steering member for transmitting biasing force of said

single spring to said steering member, and second means spaced apart from said piston and acting between said single spring and said housing for transmitting biasing force of said single spring to said housing.

27. A steering system as set forth in claim 22 wherein said spring mechanism comprises a first spring member acting between said takeoff assembly and said axle, said first spring member biasing said takeoff assembly and thereby said steering member in a first axial direction toward a straight ahead position, and a second spring member acting between said takeoff assembly and said housing, said second spring member biasing said takeoff assembly and thereby said steering member in a second axial direction opposite the first axial direction toward the straight ahead position.

28. A system as set forth in claim 27 wherein said takeoff assembly includes a piston member fixed for movement with said steering member and supported in said axle for sliding movement relative to said axle, said piston member having axially opposed first and second end surfaces, said first spring member acting between said first end surface of said takeoff assembly and said axle,

said second spring member acting between said second end surface of said takeoff assembly and said axle.

29. A steering system as set forth in claim 21 further comprising motor control circuitry operative to cause the generation of back EMF in said motor upon the occurrence of a non-driving condition of said steering system in order to resist movement of said steering member toward the straight ahead position.

30. A system as set forth in claim 21 wherein said axle has a belt opening spaced from said opening in said intermediate portion of said axle, said drive belt extending through said belt opening into said axle to transmit drive force to move said steering member axially.